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BIOLOGICAL BULLETIN.

ABNORMALITIES IN THE CESTODE *MONIEZIA* EXPANSA. I.

IMPERFECT AND PARTIAL PROGLOTTIDS.

C. M. CHILD.

IN November, 1899, a large number of specimens of *Moniezia expansa*, a common parasite of the sheep, was obtained from the Union Stockyards in Chicago. Nearly every specimen exhibited one or more abnormalities in the form of the proglottids, but one specimen, some two feet in length, was found, which possessed over a hundred abnormal proglottids. This was incomplete, for in the oldest proglottids present the uterus had not yet appeared. The abnormalities in this individual are not different in kind from those found in others, but are much more abundant. Most of the cases described were selected from this specimen.

This paper, the first of a series, is devoted to a description of some of the simpler forms of abnormal proglottids. In the second paper a number of spiral anomalies will be described, and the third will include a general summary of the facts, together with some suggestions as to causes and significance.

The figures are all drawn with the aid of the camera from stained and mounted preparations. Figs. 2-6 are magnified about fifty diameters; all others about twenty. All except Figs. 7, 14, 15, 19, and 23 are taken from the single specimen mentioned above. These five figures are selected from different individuals.

Some of the figures show the dorsal side uppermost, others the ventral. The position is noted in most cases. In each figure the furrows of the lower side are drawn as broken lines. In cases where they gradually become shallower and disappear upon the surface of the proglottid, as they often do, the attempt is made to represent the general character of the line by a lighter or finer line in the figure on the upper side, and on the lower by longer spaces between the dashes composing the broken line. In the figures of abnormalities the testes are not represented. Nearly all figures show stages before the uterus appears.

The reproductive organs are represented schematically, for the exact details of structure are not essential to the object of this paper; but the position and relation of the organs is shown as exactly as possible.

Since it will be necessary to employ various terms with reference to the segments in the course of the description and discussion of the figures, it seems advisable, in order to avoid any possible confusion, to explain briefly the nomenclature employed. The terms "proglottid" and "segment" are used as synonyms; "anterior" and "posterior" possess of course the same significance as when applied to the whole animal; "transverse" is applied as referring to the direction perpendicular to the longitudinal axis of the animal, and parallel to the two flat surfaces, the ventral and dorsal; the "width" of a segment is equal to its transverse diameter; the term "longitudinal" refers to the direction parallel to the longitudinal axis of the animal and the "length" of a proglottid is equal to its longitudinal diameter. In the form under consideration the width of a proglottid is much greater than its length. The "thickness" of a segment is its dorso-ventral diameter. "Right" and "left" are used with reference to particular figures and do not always refer to right and left sides of the body. "Side" is used as referring to the region of the proglottid indicated by the preceding adjective, *e.g.*, "dorsal side," "right side," etc. The "inter-proglottidal furrow," "inter-segmental furrow" or "furrow" is the furrow or line which separates the proglottids. A "partial proglottid" is a portion of a proglottid incompletely or completely marked off by furrows. "Partial division" refers to the

incomplete separation of two proglottids or parts of proglottids, and the "partial furrow" is the furrow separating a partial proglottid from others; it may end free or may join another furrow. In many cases the furrows gradually become less and less distinctly marked and are said to become shallow as their depth is less than that of the normal furrow.

In anticipation of the summary it seems advisable to mention briefly some of the more important facts which may be gathered from the study of these abnormalities.

Taking as the basis for comparison the normal proglottid, numerous variations from this type are found. The segment may be longer or shorter than the normal, or may vary in length in different parts. The furrows bounding the segments may end at any point, leaving two or more segments partially united, or they may bend so as to run longitudinally. The furrows are evidently the expression of internal conditions, and where abnormalities in the furrows occur, the internal organs very often show abnormalities in arrangement and position which are very closely correlated with the position and development of the furrows. In brief, the position, development, and arrangement of the sexual organs are very closely correlated with the form and size of the proglottid. The organs which lie nearer the ventral side are affected chiefly by the form relations on that side, and those which lie nearer the dorsal side by the conditions there. This appears very clearly in many cases where the form relations on the two sides of the body do not correspond. Some cases appear to indicate that a certain degree of distinctness or separation, an "internal division," may exist without the appearance of distinct furrows. Between this condition and the normal, various degrees of division are indicated by shallower or deeper furrows. The various portions of the sexual organs, *e.g.*, the proximal and distal portions of the ducts, develop independently of each other *in situ*, and become connected secondarily, or in many cases remain separated. Abnormalities of the furrows are apparently due to the internal conditions in the growing regions. The abnormalities of the internal organs must be regarded as adaptations to the abnormal relations of form, size, etc., which already exist in the segment concerned.

Figure 1.

Before proceeding to the description of the abnormalities a brief description of the normal anatomy of the proglottid is necessary. In this species the proglottids are always much wider than long, but the relation between width and length varies considerably both with age and with the degree of contraction. Fig. 1 is a figure, viewed from the ventral surface, of a normal proglottid at the stage when the testes are ripe, or a little later, *i.e.*, about the stage when fertilization occurs. The furrows between the proglottids are schematically represented by a single line here, as in most of the figures. As a matter of fact, the posterior edges of the surfaces of each segment lap over the

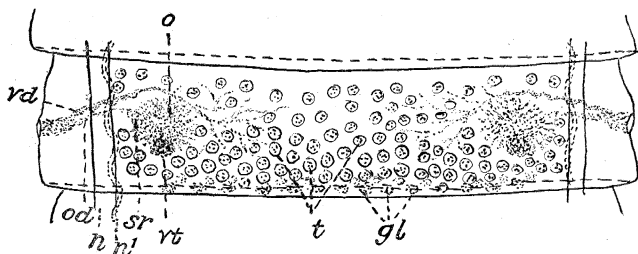


FIG. 1.

surfaces of the succeeding segment, *i.e.*, the furrow does not cut into the body perpendicularly to the surface but obliquely forward. Along the furrows on each surface, except near the edges of the segments, occur a varying number of small glands — the inter-proglottidal glands (Fig. 1, *gl.*), each of which opens by a distinct pore into the bottom of the furrow. At each side of the segment appear the two longitudinal nephridial tubes, the large ventral, *n*, and the smaller sinuous dorsal, *n'*. Transverse tubes, though visible in earlier stages, are very difficult to find later.

The terms “ventral” and “dorsal” are applied to the body of the cestode as follows: the ventral surface is the surface nearest which the ovaries and vitellaria lie, and the testes are situated near the dorsal surface.

Each proglottid possesses normally two pores lying near the middle of the two edges, but rather nearer the dorsal than the

ventral surface. The pore opens into the genital cloaca, or atrium, into which the male and female ducts also open. Following the female duct from this point, we find that it passes inward, somewhat anteriorly and dorsal to both of the nephridial tubes, then turns ventrally and posteriorly and opens into an enlarged portion, the seminal receptacle, *s.r.* Just beyond the seminal receptacle the ovary, *o.*, appears in the form of a rosette. The ovary consists of a mass of radiating branched tubules and is somewhat flattened in the same plane as the proglottid. The vitellarium, *vt.*, lies somewhat ventral and usually posterior to the ovary. At the stage shown in the figure the uterus does not appear, but in later stages it consists of an anastomosing set of tubes, which, after they receive the embryos, enlarge so as to fill nearly the whole proglottid. From this description it is seen that, although the ovary and vitellarium lie ventrally in the proglottid, the outer or distal portion of the oviduct lies dorsally. This point is important with regard to the relation of these organs in abnormal segments. Following the male duct from the atrium we find its terminal portion modified to form the cirrus. Beyond this the vas deferens, *v.d.*, follows the direction of the oviduct anterior to it, but is much coiled. It also runs dorsal to the nephridial tubes, but does not bend ventrally, as does the oviduct. Anterior to the middle region of the ovary it bends posteriorly and extends dorsal to the ovary toward the middle of the segment. Beyond the bend it begins to branch and soon breaks up into the fine tubules which connect with the testes. These latter, *t.*, lie scattered through the proglottid on the dorsal side, but are more numerous in the posterior half. They do not occur lateral to the nephridial tubes. Thus all of the male organs are nearer to the dorsal than to the ventral surface.

DESCRIPTION OF THE ABNORMALITIES.

All the figures except 7, 14, 15, 19, and 23 are taken from a single chain. These five are taken from as many different chains, and on comparing them with the other figures it becomes evident that the abnormalities found so abundantly in the one specimen do occur, though less frequently, in very many individuals.

The figures all represent cases of partial division of segments, together with the accompanying abnormalities in the form and position of the genital organs. A classification is difficult, and, I think, unnecessary. In general the more simple and regular cases are discussed first, the complex ones later. Cases resembling each other are grouped together as far as possible.

Figs. 2-6 are taken from various points near the anterior end of the chain. They all show stages before the appearance of the genital organs. These cases, although differing somewhat in form, are grouped together here as furnishing some evidence for the conclusion that the abnormalities of this kind appear at the time the furrows are formed and are not due to a later division of proglottids. They are certainly as common in these earlier stages as in later ones. Following these are grouped the cases in which the furrows on the two surfaces correspond closely. These include Figs. 7-15, as well as Figs. 2, 3, 5, and 6 of the preceding group. In Figs. 7-15 the genital organs, though they may be abnormal in position, are nearly always fully developed. The remaining figures, 16-23, show cases which are more complex and in which the furrows on the two surfaces do not usually correspond. Moreover, in these cases some of the genital organs are commonly rudimentary or abnormally developed.

Figure 2.

This figure was taken from the extreme anterior end of the body. The furrows between the proglottids have become fairly

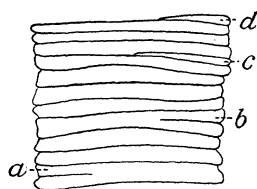


FIG. 2.

distinct. As the dorsal and ventral furrows correspond exactly in position, only one surface is represented in the figure. Four abnormal segments, *a*, *b*, *c*, and *d*, are present. The segments *a* and *b* are both examples of partial division, one upon the right side, the other on the left. Here the partial furrows end free, not far from the middle of the segment in which they occur, so that the proglottid appears as if partially split from one edge. The two cases at the anterior

end, *c* and *d*, consist of partial segments on the right side. The separation of these is complete on both sides of the body.

Figure 3.

In this case two proglottids are incompletely separated on the upper side, because the furrow on the right side is slightly anterior to that on the left. The two parts of the furrow overlap slightly, *i.e.*, the left part extends past the inner end of the right part, and each ends free. On the lower side the furrow at the right bends anteriorly and meets the complete furrow anterior to it, thus marking off completely the small partial segment. The longer partial furrows correspond exactly on the two surfaces. Apparently the right and left portions of the furrows have been formed independently and have failed to meet.

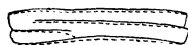


FIG. 3.

Figure 4.

In the segment *a* this figure shows a case where the segment is of less than normal length at the left edge, and where, moreover, the bounding furrows on the lower surface do not extend to the edge but bend so as to meet on the surface of the segment a short distance from the edge.

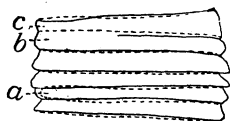


FIG. 4.

In *b* and *c* a rather simple case of partial division is represented. The partial furrow on the upper surface extends from the right edge to a point near the middle of the segment and there ends. At the left there is no furrow on the upper surface corresponding to this one, so the whole left half appears undivided. On the lower surface, however, the furrow between *b* and *c* is normal, extending across the whole body, meeting the upper furrow at the right edge and ending in a slight indentation on the left edge. At the right *c* is about twice as long as *b*, but at the left *b* is much the longer of the two. This difference is due to the fact that the furrows anterior to *c* are somewhat oblique.

Figure 5.

In this figure two variations from the normal form occur, both cases of incomplete separation or partial division. The partial segment *a* is completely separated on the upper surface from the segment in front, and its inner end is rounded, but on the lower surface the furrow between the two ends free, so that the separation is incomplete here. The segments *b* and *c* are

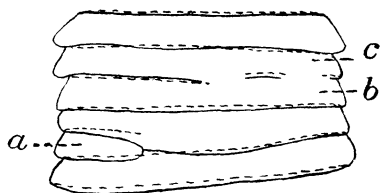


FIG. 5.

incompletely separated by four distinct partial furrows, all of which, however, lie in the same transverse plane and must be regarded as portions of a single furrow. The largest portion is at the left side, extending to the middle of the body on each

surface and of normal depth throughout. To the right of the middle a short partial furrow appears on each surface, the two being equal in length and in corresponding positions. At the right edge is a very short partial furrow marking off the two segments at the edge, but extending only a very short distance on either surface. The length on the two opposite surfaces of all the partial furrows, and especially of the two short entirely unconnected parts, is a point of interest. It is quite commonly, though by no means universally, the case that partial furrows, when they occur on the two surfaces, are of the same length on both.

Figure 6.

At the stage shown here the inter-proglottidal glands have begun to appear in the furrows between the segments. This case shows a rather unusual form of partial proglottid. The part *a* is completely marked off on both dorsal and ventral sides from the rest of the proglottid by the transverse furrow between *a* and *c*, and by the nearly longitudinal furrow between *a* and *b*, thus forming a small, distinct, partial proglottid. The transverse furrow extends somewhat beyond the point where the longitudinal line joins it, thus partially separating a small portion, *b*, from

the remainder of the proglottid. At *d* a triangular depression appears in consequence of the fact that the contours of the portions *a*, *b*, and *c* are somewhat rounded at this point where all three meet. The same conditions are present in some degree on the lower surface also, so that the thickness of the body at *d* is very slight.

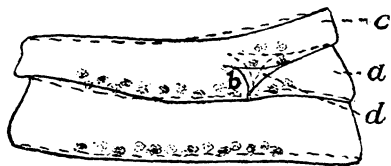


FIG. 6.

Inter-proglottidal glands appear just anterior to the extra trans-

verse furrow, thus showing the same relation to it as to the normal complete furrow. This is usually the case, provided the abnormal furrow attains a certain degree of depth.

Figure 7.

This is a case of partial division seen from the ventral side. The segment is undivided at the left, and one genital mass appears. To the right of the middle, however, a short partial furrow appears on each surface, the two corresponding closely in position. The right edge shows clearly a division into two segments, and a very short furrow extends from it on to the ventral surface. In accordance with these indications of division in the right half two genital masses appear.

The fact that the two partial furrows correspond so closely on the two surfaces indicates that they are distinctly the result of internal conditions. Judging from the existence of the two genital



FIG. 7.

masses and the short furrow at the right edge, it appears probable that division or separation exists in a certain degree between the two regions, even where the actual furrows do not

appear. Many other cases support this view. It would appear that the individuality of the segment must attain a certain degree of development in order to cause the formation of furrows, and that, where only partial furrows exist, the division may be in many cases more complete than the furrows indicate.

The short furrows on the two surfaces bear inter-proglottidal glands like the complete furrows.

Figure 8.

This case, though at a later stage of development than Fig. 7, resembles it. Two partial furrows appear, one on the dorsal, the other on the ventral surface, corresponding exactly in position and length, but entirely unconnected. The exact correspondence in position and length of these two entirely unconnected furrows indicates very clearly, as does the similar condition in Fig. 7, that



FIG. 8.

the position of the furrows is determined by internal conditions, for it is difficult to understand how two perfectly similar partial furrows could arise on opposite surfaces of the body except

as the expression of certain internal form-producing conditions.

The genital organs are duplicated on the left side, but the two pores are approximated. The individuality of the two portions is apparently not sufficient to give rise to furrows at the edge, so that pores tend to appear near the middle of the edge. But the furrows extend almost to the edge, and the existence of two pores is undoubtedly the result of this position. The right side shows no trace of duplication.

Figure 9.

This figure shows three cases of partial division, and in all the partial furrows end free and correspond

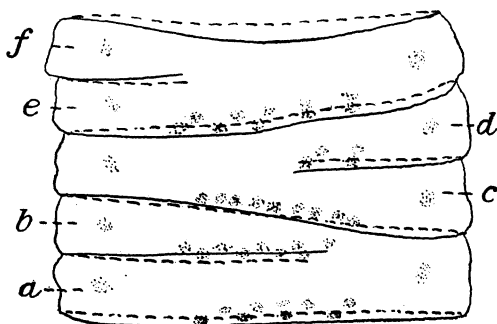


FIG. 9.

on the two surfaces. The partial furrows between *a* and *b* are most nearly complete, extending past the middle of the body. Between *c* and *d* they are shorter, and between *e* and *f* still shorter. In each case the two partial segments are longer than the corresponding single segment at the opposite edge, consequently oblique furrows appear between the three sets, but,

owing to the alternation in position of the partially divided regions, the length of the right and left edges of the whole group is the same, *i.e.*, the abnormality in form of each segment compensates for that of the others. Each partial proglottid possesses its own genital mass, so that there are five on the left side of the group and four on the right. All partial furrows that are long enough, *i.e.*, all except that between *e* and *f*, show interproglottidal glands, and all are of normal depth and distinctness. The decreasing length of the partial furrows from the posterior to the anterior set is noticeable, but whether it possesses any special significance or not is not clear.

Figure 10.

Four cases of partial division of proglottids occur here, three on the left and one on the right (*a*, *b*, *c*, *d*). In each case the partial furrows on the two surfaces correspond almost perfectly in position and length and end free, not far from the middle of the body. The relations at the edges do not differ from the normal except in the case of *b* at the right. This proglottid is partially divided at the left, but the undivided portion to the right is as long as the two partial proglottids at the left, though no furrows appear. The complete genital mass *g* appears at the normal distance from the furrows bounding the segment posteriorly, and

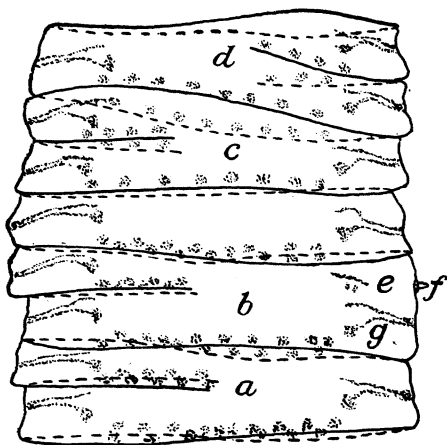


FIG. 10.

a partial second set of organs, *e*, *f*, appears in the anterior region, consisting of the inner portion of the vas deferens, *e*, two small groups of cells just posterior to it, which probably represent the inner portion of the oviduct or the ovary, and entirely unconnected with these at the right edge a pore with

protruded cirrus, *f*, which has probably been forced out through the pore by the pressure during fixation. Here then is a complete set of genital organs and a second partial set occurring without any furrows between them. This condition is rare. I have found only one other similar case.

This appears to be a duplication of genital organs in a proglottid which is morphologically single, at least in its right half. I believe, however, that this case is simply another example of the fact that a certain degree of individuality may exist without the appearance of furrows, but may still be quite sufficient to lead to the partial formation of genital organs. The fact that the proglottid is divided on the left side into two parts by partial furrows of normal depth affords additional evidence for this view. It is evident that the causes leading to the formation of genital organs at *e* and *f* is much less efficient than normally, for the organs are extremely rudimentary and can never function in the normal manner.

The presence of furrows on the surface is, in general, simply the morphological expression of certain internal conditions. These relations differ in degree in different species, and, as is evident from the variations discussed in this paper, in this species also. This being the case, the logical conclusion seems to be that a certain degree of isolation or individuality may exist without the appearance of furrows on the surface.

In this rudimentary and incomplete set of organs, *e* and *f*, it is seen that the two parts, *e* and *f*, arise independently of each other. The pore and cirrus are absolutely unconnected with the inner portions of the ducts which are present. These facts show that the proximal and distal portions of the genital organs arise independently *in situ*, in, or as nearly as possible in, the position which is normal for each.

The cells of the incomplete set show the same degree of differentiation and the same reaction to the stain as the corresponding regions of the complete set, *g*. It seems probable, therefore, that both sets were formed at the same time. The differences between the two sets consist in the entire absence from the one of certain parts present in the other. As will appear below, a segment of less than normal length usually possesses only partial

genital organs. Here no actual furrows are present, but the relative positions of the two sets of organs, *g* and *e f*, indicate that the set *g* corresponds to a longer portion of *b* than does the set *e f*.

Inter-proglottidal glands appear in all of the partial furrows.

Figure 11.

This figure, representing a case of partial division, shows very distinctly an almost complete gradation in individuality from the right to the left, as indicated by the arrangement of the organs. At the right the partial furrows separate the segments in a normal manner, but the posterior segment is the shorter. Correspond-

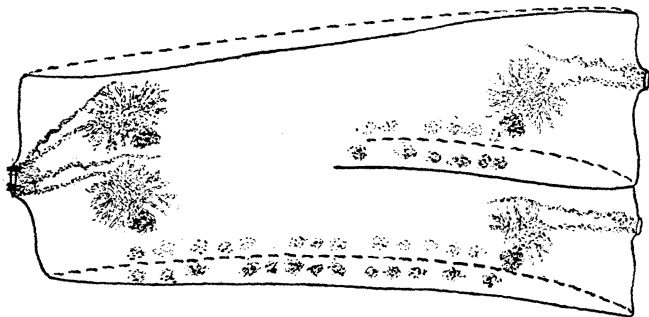


FIG. 11.

ing to the position of the furrows, two complete sets of organs appear on this side, but the posterior set, especially the ovary, is smaller and less fully developed than the anterior.

The partial furrows end, however, near the middle of the body, leaving the left half apparently undivided, and the left edge is considerably shorter than the right. That the two segments possess a certain degree of individuality beyond the region where the furrows end is indicated by the presence of two complete sets of organs and ducts, which are, however, closely approximated and open through a single pore situated at the middle of the undivided edge. Even the terminal portions of the two sets of ducts are distinct and two cirri are present. To judge from the arrangement of the organs it appears that from right to left the segments are less and less completely separated, until at the left edge the

conditions are nearly those of a single normal segment, so that only a single pore appears.

Inter-proglottidal glands lie in the partial furrows on each surface.

Figure 12.

The figure, a view from dorsal surface, shows three segments which are all incompletely separated at the right side. At the left the separation is complete, the furrows appear normal, and the genital organs in process of formation are normal in position and form. On the right the furrows separating the segments *a* and *b* end at *d* and *e*, before reaching the edge, the furrow on the ventral side becoming shallow and rather irregular in its

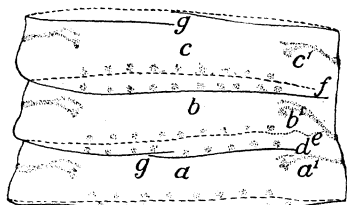


FIG. 12.

course (*e*) but extending almost to the edge, while the dorsal furrow ends more abruptly at a greater distance from the edge (*d*). The furrows between the segments *b* and *c* do not reach the right edge, but end rather abruptly near it at *f*, the points of

termination on the two surfaces of the body being about equidistant from the edge. Thus the whole right edge shows no traces of division into separate segments, but nevertheless possesses three genital pores, two of which are near together. The ovaries and vitellaria and the inner ends of the vasa deferentia at the right of *a* and *b* are normally situated with regard to the furrows, for at this distance from the edge the relations are practically those of two normally distinct proglottids. As we approach the right edge, however, the dorsal furrow, *d*, ends abruptly at some distance from the edge, while the ventral furrow, *e*, becomes more shallow and finally disappears near the edge. The terminal portions of the ducts lying nearer the dorsal surface are affected in greater degree by the relations on the dorsal surface, and we find here that as the ducts approach the edge they also approach each other, the approximation being almost wholly due to the abnormal direction of the ducts of the set *b'*. The organs at *a'* lie in the normal position, but those at *b'* lie

obliquely in their segment, the ducts extending outward and posteriorly toward the pore; but these positions are, I believe, due to the relations of the segments to each other. The fact must be recognized that in segments of normal length a complete set of organs capable of functioning tends to form, however abnormal its position; *i.e.*, the parts are formed independently and tend to unite in the normal manner. In this case the proximal portions of the organs *a'* and *b'* are formed in their normal position with respect to the furrows bounding the segment ventrally. The edge of *a b* shows no dividing furrow, so that it might be expected that a pore would appear at its middle. The furrows *d* and *e* approach near the edge, however, and the existence of a certain degree of "internal division" at the edge is probable. Thus two pores are formed instead of one, but are separated by less than the normal distance between pores of two successive segments. Apparently the degree of separation between the two segments at the edge is only slight, so that the edge is more or less like that of a single segment, and the middle region is the pore-forming region. But the two segments are sufficiently independent to give rise to two pores instead of one common to both; and these two pores, it will be noticed, are equidistant from the middle of the undivided edge of *a b*. But the pore in *b* is far posterior to the ovary, etc., and in order that the two may be connected the ducts must extend obliquely, as they do. In *a*, on the other hand, the pore is directly lateral to the proximal portions, and thus the ducts are horizontal.

The furrows between *b* and *c* extend almost to the edge, so that conditions here approach very closely to the normal. The organs *c'* in *c* are normally situated as if the furrow *f* were complete.

Two of the furrows on the dorsal surface are interrupted (*g g*) and the two parts overlap slightly in each case.

Figure 13.

The variation from the normal form shown here is almost identical with that shown in Fig. 12, *a* and *b*, except that here the two partial furrows bend anteriorly at the right. Both become

shallow and indistinct and terminate on the surface near the right edge. As in Fig. 12, *a* and *b*, two complete sets of genital organs appear on the right side, the posterior set being normal and the anterior set situated somewhat obliquely, with the pore

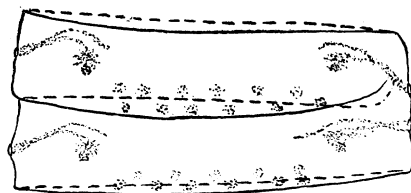


FIG. 13.

near that of the posterior set. The positions of the two sets of organs are undoubtedly the result of conditions similar to those in Fig. 12, *a* and *b*, and are to be explained in the same way.

It is noticeable that the curve at the right ends of the furrows appears to have no significance as regards the position of the organs, which are situated as they would be if the furrows ended without bending forward. The furrows become very slight here, being little more than wrinkles on the surface.

Figure 14.

Two cases of partial division, *a b* and *c d*, are shown in this figure, viewed from the ventral surface. The partial furrows on the two surfaces correspond in both cases. Between *a* and *b* they extend from the left edge to a point just beyond the middle of the body, thus leaving almost the right half undivided, and, corresponding to the partial division, one set of organs is found

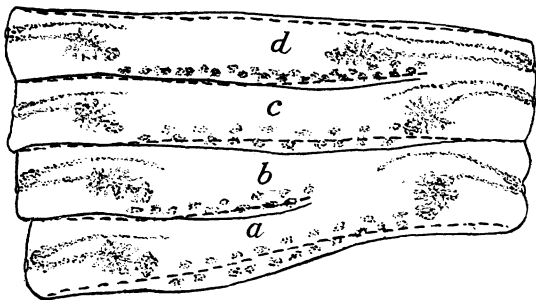


FIG. 14.

at the right, while two appear at the left. The division between *c* and *d* is more complete, extending from the left edge over about three-quarters of the width of the body, and in this case, although the right edge itself shows no furrow, two sets of organs occur at the right as well as at the left, but their pores are much

nearer together than at the left, where the separation of the segments is complete and normal. It appears from the arrangement of the organs at the right that the two segments *c* and *d* do preserve a certain degree of individuality in the region beyond the end of the partial furrows, for if this were not the case we should expect to find only one pore instead of two, a condition which does frequently occur. The position of the ovary and vitellarium at the right of *d* is peculiar. The ducts, instead of bending posteriorly, extend straight inward, and the ovary lies nearer the middle of the segment than the others. This position is apparently due to the form relations here. The distal portions of the two sets of organs at the right of *c* and *d* are approximated, but the partial furrows between *c* and *d* extend to the region of the ovaries, and *d* is slightly shorter in this region than *c*, so that the ovary and vitellarium in *d* take the position in which they can attain most nearly their normal development.

Inter-proglottidal glands occur in the partial furrows as well as in those which are complete.

Figure 15.

This figure shows a case of partial division in which the partial furrows are nearly complete. The segments are rather old, the ovaries and ducts being in process of degeneration and the uterus containing embryos (not drawn in figure).

At the left side the segments are normally bounded, and the genital organs are apparently normal. At the right the partial

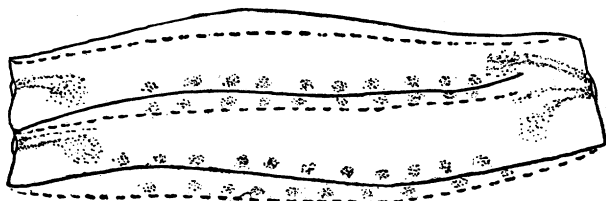


FIG. 15.

furrows end before reaching the edge, and two sets of organs occur, opening into a common pore. The partial furrows extend so nearly to the edge that in the ovarian region the two segments

appear almost normally separated, and accordingly two sets of organs appear. The edge, however, is undivided and shorter than the combined length of the two segments at the left, and only a single pore is formed, into which both sets open. This case shows much the same gradation from complete division to almost complete union, as is found in Fig. 11, but here the gradation occurs within a much shorter distance, for the furrows are nearly complete, while in Fig. 11 they extend only halfway across the body.

Figure 16.

The figure represents a peculiar case of partial division seen from the dorsal side. The two segments are completely separated at the left by partial furrows which extend to the middle on each surface. Corresponding to this separation we find two

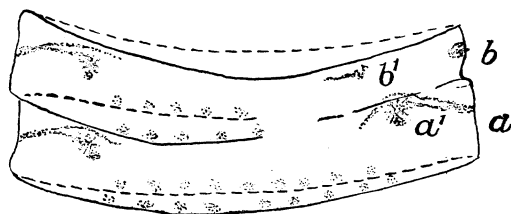


FIG. 16.

complete sets of genital organs. On the right the two portions are separated dorsally by a very shallow furrow which is interrupted at several points.

This furrow passes the right edge and extends for a very short distance on the ventral surface, leaving all the rest of the right half of the ventral surface undivided. Corresponding to this incomplete separation we find abnormalities in the genital organs. There is one complete set of organs (*a'*) in the posterior segment, and portions of a second set (*b'*) in the anterior segment.

The ovary, vitellarium, and inner end of the vas deferens of *a'* lie nearly in the middle of the undivided ventral side, almost directly beneath the shallow interrupted furrow on the dorsal surface, thus indicating that their position is more directly affected by the conditions of the surface to which they are nearest, *viz.*, the ventral. The pore and atrium, on the other hand, appear on the edge of *a*, nearer the anterior than the posterior end. The partial furrow on the dorsal surface and the right edge is very slight, *i.e.*, the two partial segments, though

separated to a certain degree on this side, are still much less distinct than normal segments, and the pores and terminal portions of the ducts of *a'* are therefore found in a position only a little posterior to that which they would occupy if *a* and *b* were not separated at all.

The partial segment *b*, as marked off by the slight and interrupted dorsal furrow, is narrower than *a*. The complete set of organs, *a'*, lies nearly in the middle of *a b*, but since the two segments are sufficiently distinct dorsally for the formation of a slight furrow, there is a certain tendency for another set of those organs which lie near the dorsal surface to form in *b*, as is indicated by the presence of a pore with atrium and cirrus at the edge, and the inner portion of the vas deferens at *b'*. These parts are wholly unconnected, and there is no trace of female organs. The failure to develop a complete vas deferens is probably due to the fact that the segment *b*, as bounded dorsally, is of less than normal length and imperfectly separated from *a*. The parts of the male organs which do appear are identical with those which we find in Fig. 10, *b*, but in that case there is a trace of female organs also. These two cases are examples of a condition often found in short, imperfectly separated segments, *viz.*, the development of the innermost and outermost portions of the organs without connection. It appears as if the region of the pore and the inner portions of the ducts represent, as it were, the places of least resistance with respect to the formation of the genital organs, so that segments which are not sufficiently normal to give rise to a complete functional set of organs may form these two parts, but not the ducts connecting them.

The complete absence of female organs at the right of *b* shows very clearly that the formation of the ovary and vitellarium is connected with the conditions on the ventral side of the body, and the formation of the vas deferens with conditions on the dorsal side.

The shallow dorsal interrupted furrow at the right is without inter-proglottidal glands, probably because of its slight development.

Figure 17.

The figure represents two partially separated segments seen from the dorsal surface. At the right the division is complete and the genital organs are normal.

The ventral furrow extends without interruption about three-quarters across the ventral surface, but is somewhat irregular in its course. The dorsal furrow is interrupted at two points, once just to the right of the middle and again near the left side, leaving a short portion, *c*, entirely separated from the rest. This portion does not reach the left edge, but turns anteriorly near it and ends abruptly. The ventral furrow shows no portion corresponding to this portion, *c*, consequently the segments are

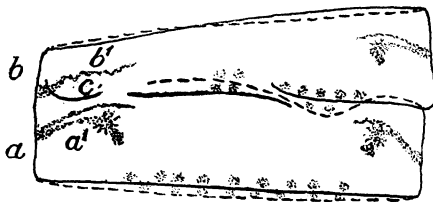


FIG. 17.

visibly separated only on the dorsal surface in this region. The abnormal relations of the furrows are accompanied by abnormal conditions in the genital organs. The case is somewhat similar to the one

appearing in Fig. 16, and confirms the conclusions reached in the discussion of that case. The posterior portion, *a*, is longer than *b* and possesses a normal set of organs normally situated, while in *b* there is a complete vas deferens and pore, but no trace of ovary, vitellarium, or oviduct. Analysis shows a very close relation between the organs and furrows. The case is very similar to Fig. 16, but presents some differences. The partial furrow *c* is dorsal, but is deeper than the furrow in Fig. 16; *i.e.*, the division between *a* and *b* is a little more complete here than there, and the ovary and vitellarium of *a* lie further posteriorly. A second set of female organs does not appear, probably because the region *b* is not separated from *a* on the ventral side and is considerably shorter than *a*, so that the single ovary and vitellarium serves for the whole length of *a b*. On the dorsal surface the partial furrow *c* shows that different relations exist, and here in the shorter portion, *b*, there is formed a complete vas deferens and pore. The pores in *a* and *b* are

approximated, this being apparently due to the fact that the division is incomplete and the furrow *c* does not reach the extreme edge. Comparison of this figure with Fig. 16 is very instructive. The relations of the furrows at the left of Fig. 17 are almost the same as at the right of Fig. 16, the chief visible differences being that in Fig. 16 the furrow is shallower, but passes over the edge, while in Fig. 17 it is of normal depth but does not extend to the edge. In both cases the corresponding portions of the ventral surfaces are without furrows. As regards the genital organs in the shorter anterior portion *b* in the two cases, we find in Fig. 16, where the dorsal furrow is shallow, only the inner portion of the vas deferens and the pore appear, the two being entirely unconnected, while in Fig. 17, where the dorsal furrow is deeper and thus more nearly normal, a complete vas deferens is formed connected with its pore. Moreover, in Fig. 17 the furrow does not reach the edge, and the pore in it is situated somewhat posteriorly, while in Fig. 16, where the furrow passes the edge, the pore is in the middle of the edge of *b*. In neither case does the region *b* show any trace of female organs. The conclusions regarding the causes of the conditions in Fig. 16 apply with equal force here. To my mind these two cases afford ample basis for the views expressed in this paper, but these are supported and confirmed by a mass of evidence from the other abnormalities discussed here, so that the conclusions reached become not only probable, but, I believe, incontestable.

Figure 18.

In this case a small partial segment is completely marked off by very slight furrows, and the anterior furrows show a very abrupt bend where the partial segment ends. In the complete segment lying just posterior the genital organs are normal, but in the small partial segment nothing but two small groups of cells appear, and it is impossible to determine just what portion of the organs they represent. The pore is entirely absent.

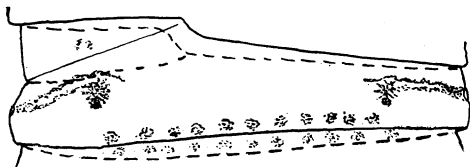


FIG. 18.

Figure 19.

In these segments the ovaries and ducts are degenerating, and the embryos are in the uterus (not shown in figure). The two segments seen from the ventral surface are incompletely separated ventrally by a partial furrow which does not reach the left edge. Dorsally the furrow between the two is complete. At the right the segments and genital organs are normal. At the left *a* is longer than *b* and is separated from it only dorsally. In *a* a complete set of organs appears, but situated somewhat farther anteriorly than the normal position, *i.e.*, approaching

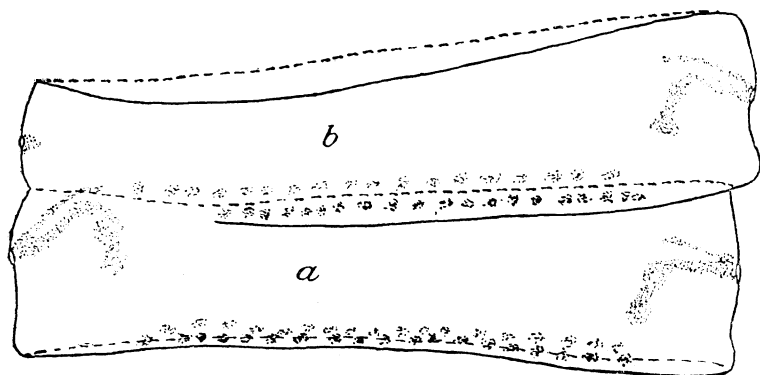


FIG. 19.

the middle of the undivided region of *a b*. The dorsal boundary between *a* and *b* is normal at the left, and the edge is divided, and in *a* we find a pore almost normally situated with respect to the form of the dorsal surface. In the shorter segment *b* the only indication of genital organs at the left is a pore, but this is placed nearly in the middle of the edge of *b*, *i.e.*, almost normally with respect to the dorsal boundaries. The fact that no other organs appear here is doubtless due to the shortness of this portion of the segment *b* and to its imperfect separation from *a*. As seen in Figs. 10, *b*, 16, 17, and 18, imperfectly separated segments of less than normal length usually possess more or less rudimentary organs. As noted, the two pores at the left of *a* and *b* are not quite in their normal positions, *i.e.*, they are separated by less than the normal distance, as is evident from a

comparison with the pores at the right. This approximation of the pores is evidently due to the incomplete separation of the two segments, which, though separated dorsally, are united ventrally. Thus, while the existence of the pores seems to be determined by the relations upon the dorsal surface, their position may be affected in some slight degree by the relations on the ventral surface.

Figure 20.

The series of abnormalities shown here is rather complex and may be considered most conveniently segment by segment. The ventral surface is uppermost.

The segment *a* is partially divided on the left side by a furrow which extends from a point on the ventral surface very near the edge around the edge to the dorsal surface, and for a short distance on the dorsal surface, where it ends free. The degree of separation is sufficient to cause the appearance of two distinct and complete sets of genital organs. At the edge the division is complete, and accordingly the pores lie in practically their normal positions on each side of it. The division, as indicated by the furrow, extends only a short distance on either surface, but farther on the dorsal than on the ventral surface, and the arrangement of the ducts, ovaries, etc., is in accord with these relations. The two ovaries, etc., are quite closely approximated, but the ducts diverge, thus indicating that the division becomes more complete with the approach of the edge. This case, like Fig. 10, *b* and *c*, illustrates, though in a less degree, the apparent existence of a certain degree of separation in regions where the furrows do not appear. Thus there is no furrow on either side immediately between the ovaries, yet two sets appear. That the division is more complete dorsally than ventrally is shown by the fact that the dorsal furrow is longer than the ventral, and the position of the genital organs accords with this fact as shown above. At the right *a* shows no trace of division, and a single normal set of organs is present.

The segments *b* and *c* are best considered together. At the right, before reaching the edge, both the dorsal and ventral furrows separating *b* and *c* bend anteriorly and become very slight,

being mere wrinkles on the surface. The ventral furrow can be traced to the anterior boundary of *c*, where it ends very near the edge, while the dorsal furrow ends free about midway of the segment. Thus the segment *c*, as bounded by the very shallow curved furrows, does not reach the right edge of the body at all on the ventral surface, and dorsally extends to the edge only anterior to the end of the curved furrow. The portion forming the edge is not separated from *b*. At the left the ventral furrow

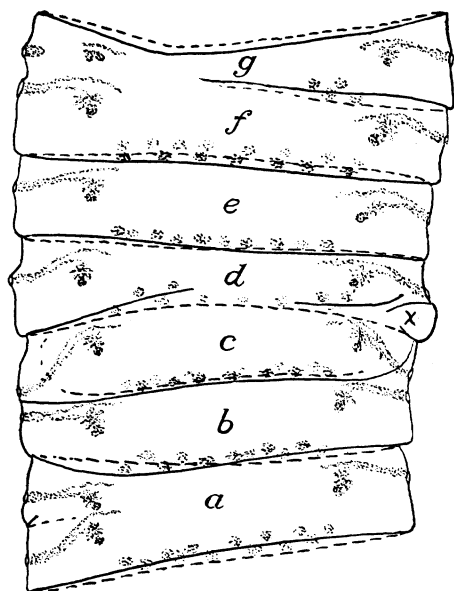


FIG. 20.

between *b* and *c* reaches the edge normally, but ends there, for the dorsal furrow, instead of extending to the edge and meeting the ventral, bends forward like the right ends of the furrows and becomes like them very shallow, a mere wrinkle, which is visible to the anterior end of the segment. Thus the portion forming the left edge in the region of *c* is connected on the ventral surface with *c*, but dorsally only with *b*, *i.e.*, there is a short spiral here. This

case shows how a spiral may arise by the bending forward of one of the furrows to meet the next in front, instead of uniting with its fellow on the opposite surface. In nearly every case of spiral variation this bend occurs as it does here near the edge, though in many cases the furrow remains of normal depth. This case then is what may be called an incipient spiral modification.

The spiral does not appear between *c* and *b* at the right, simply because both furrows bend forward, though the furrow does not completely separate the two segments, but ends free. The furrows anterior to *c* must be considered briefly before turning to the discussion of the genital organs of *b* and *c*. The dorsal

furrow is complete and takes a slightly curved course, but the ventral is divided into three parts. At the left one portion extends from the edge obliquely inward and anteriorly to a point near the middle, where it ends. The second portion lies on the right side, is almost transverse, and extends nearly to the right edge, overlapping with the third portion which reaches the edge at a point anterior to the corresponding dorsal furrow. Upon the edge it turns posteriorly and passes backward to the point where the dorsal furrow reaches the edge, and there it turns inward again, extends for a short distance, and terminates freely, thus almost surrounding a small region on the ventral surface at *x*. Notwithstanding these irregularities the furrows between *c* and *d* approximate to the normal conditions, but the ventral furrow is a little anterior to the dorsal, except in the short portion posterior to *x*. At the right relations are normal.

Returning now to the genital organs in the segments *b* and *c*, we find in each segment a complete set on each side. Considering first the organs in the left side of *b* and *c*, it is seen that in *b* the inner portions are normally placed, but the pore lies rather more anteriorly than its normal position. As noted above, there is a short spiral here owing to the course of the dorsal furrow in *c*, and the edge corresponding to *c* is not separated dorsally from *b*. This accounts for the position of the pore in *b*; *i.e.*, the organs in *c* are situated very much as they would be if there were no dorsal furrow at all between *b* and *c* in this region. The only indication of division on the dorsal surface in the region of the ducts is the very slight furrow curving forward. This seems not to affect the course of the ducts at all, for they cross it at right angles to reach the edge. The extreme posterior position of the pore in *c*, *i.e.*, its approximation to that of *b*, is evidently due to the same causes as the displacement of the pore in *b*, *viz.*, the absence of dorsal division in this region.

At the right in *b* and *c* somewhat similar conditions exist. The positions of the inner portions of the organs are about normal. As regards ducts and pores on the right, there is the same approximation as on the left. This end of the dorsal furrow in *c* is incomplete, ending, after bending forward, free on the surface just dorsal to the middle region of the ducts, and the ventral fur-

row also bends forward. The ducts in *c*, however, are situated as if the curved portions of the furrows were not present; that is, as if the furrows, especially the dorsal, ended about where they begin to bend.

The right edge corresponding to *b* and *c* is undivided, and the pores are accordingly approximated as on the left side. The separation of the two segments is normal up to within a short distance of the edge, and thus probably determines the existence of two separate pores, instead of the union of the two sets of organs in one.

The significance of the curved ends of the furrows in *c* requires a brief consideration. As mentioned above, they are very slight, being mere wrinkles, and though they are continuous with the normal inter-proglottidal furrows, they are not like these in appearance. The position of the genital organs does not appear to bear any direct relation to them, for the ducts cross them to reach the edge. Undoubtedly the slight development of these curved ends indicates a very incomplete separation of the parts which they bound, and, as will appear later, it is possible that such furrows do not always coincide with the real segmental boundaries.

The position of the organs in *c* and *d* appears to be nearly normal. At the right the pore lies very near the end of the abnormal ventral furrow, but about in the middle of the edge, as bounded dorsally, thus showing that its position is determined, at least largely, by the relations on the dorsal side. At the left the pore is approximate to the pore in *b*, evidently because of the absence of division on the dorsal surface at the edge.

The segment *e* is apparently perfectly normal, but *f* and *g* show abnormal relations, being separated on the right but united on the left. The partial furrows extend from the right edge a short distance past the middle of each surface and end free, the terminal portions being shallower than the rest. Thus the left side is without any true furrows, but the surface shows certain indications of a division between the two parts. From the end of the furrows to the edge there extends a depression in each surface too broad and indistinct to be called a furrow, but still apparently indicating a certain degree of separation (not shown in the figure). It reaches the edge in the slight depression between the two

pores at the left of the figure. The existence of this line of depression indicates, I believe, that *f* and *g* are really more or less distinct segments, even on the left, where no true furrow occurs. At the right *g* is as long as *f*, but is shorter at the left, and the furrows bounding it anteriorly are abnormal, for they are not transverse but extend from each edge somewhat posteriorly, thus making *g* very narrow just to the left of the middle. At the right the genital organs in *f* and *g* are normal and normally placed. At the left the organs in *f* are situated a little anterior to their normal position. We find, however, a second partial set of organs anterior to the first and showing relations almost identical with the rudimentary organs in *b* in Figs. 10, 16, and 17. The inner portion of the vas deferens appears, and just posterior to it lie small groups of cells which apparently represent a portion of the female organs. These parts are, however, entirely unconnected with the cirrus and pore, which are of normal size and appearance. Here again the inner and the outer portions have developed independently of each other, and the connecting ducts are absent. This case differs from those in Figs. 16 and 17, and resembles that in Fig. 10, *b*, in that a portion of the female organs appears here. In Figs. 16, *b*, and 17, *b*, a distinct furrow occurs on the dorsal side, but there are none ventrally; this condition indicating a more complete separation on the dorsal side than on the ventral, while in Fig. 10, *b*, as in this case, distinct furrows are absent on both sides in the immediate region concerned. Probably portions of both female and male organs occur in these cases, because the degree of separation, though slight, is the same on both sides. The incompleteness of the organs is doubtless due here, as in the other cases, to the small size of the segment.

The interproglottidal glands appear on all the furrows which lie within the zone of their formation. In the furrows between *f* and *g*, however, they are found only near the right side. The terminal portions of the furrows are shallow, and thus apparently insufficient to cause the glands to appear.

The region from which this figure was taken is not exceptionally abnormal, but was selected because it presents a number of different kinds of abnormalities near together.

Figure 21.

The figure represents four incompletely separated proglottids seen from the ventral surface. Between *a* and *b* the furrows at the left meet at the edge and extend over about one-third of each surface, ending free. At the right a peculiar curved furrow appears on each surface, and on the dorsal surface an oblique furrow extends posteriorly over *a* from the curved position almost to the posterior boundary of the segment. In accordance with the relation of the furrows, the genital organs at the left are

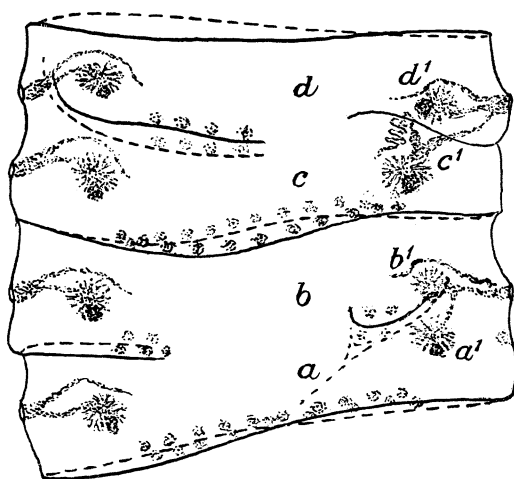


FIG. 21.

normal, but on the right side of *a b* a peculiar set of abnormalities appears. Two distinct ovaries and vitellaria, *a'* and *b'*, appear, one in *a*, the other in *b*, but there is only one vas deferens, that in *b*. The oviduct from *a'* extends anteriorly and unites with the oviduct of *b'* near the seminal receptacle, and the com-

mon duct opens through the pore in *b*. In a number of cases I have found two sets of organs opening through a common pore, but the union of oviducts at a point so far from the pore is rare. The organs *a'* consist wholly of female organs, the vas deferens being entirely absent. It will be noted that the partial furrow on the dorsal surface in this region takes an oblique course. The right end of the curved partial furrow on the ventral surface takes a similar course. The ovary *a'* lies quite near these furrows and consequently there is no space for the development of the vas deferens in anything like its normal position. As the relative position of the various organs appears to be quite definitely determined in all cases, there is probably no tendency

for the vas deferens to appear at all when it cannot be formed somewhere near its normal position. The partial furrows end just between the ovaries of a' and b' , and accordingly the two are quite closely approximated. This may be another reason why the vas deferens does not appear in a' , and it is, I believe, because of this approximation that the oviduct of a' unites with that of b' instead of running independently to the surface. There is a small rudimentary pore on the right edge of a which is wholly unconnected with the ovary a' , thus showing again the tendency for the terminal portions of the genital organs to develop separately in the segments of a low degree of individuality. The genital organs, b' , appear normal in form and constitution. The vas deferens is present here and in its normal relations. The pores in a and b are somewhat approximated, owing, apparently, to the fact that the edge is undivided, though division exists a short distance from it.

Between c and d at the right there is a distinct, though rather slight, furrow only on the ventral surface, and this furrow becomes somewhat oblique a short distance from the edge, *i.e.*, it extends somewhat anteriorly from the edge toward the middle. Its slight development is not clearly shown in the figure, but it is much less deep than the normal furrow. Dorsally there is no distinct furrow but only a shallow depression extending in the same direction as the furrow on the ventral surface and terminating in the corresponding region (not shown in the figure). As in the case of Fig. 20, f and g , I believe this depression represents what might be called a very rudimentary furrow, and its correspondence in this case with a distinct furrow on the ventral surface supports this view as regards both this case and Fig. 20. The genital organs, c' and d' , show peculiar relations. There are two complete sets opening by a common pore in d' . In c' , however, the vas deferens does not extend to the pore at all, but forms a complex coil just anterior to the ovary and *apparently opens directly into the seminal receptacle*. A small cirrus appears to be present in the enlarged terminal portion of the male duct which is seen in the figure. This is the only case where such a relation of the male and female organs has been found, unless it occurs on the left side of e , Fig. 22, where

it is impossible to determine the exact relations. In the organs at *c'* the portion of the seminal receptacle which lies between the ovary and the point of union of the male and female ducts is full of spermatozoa, while the outer portion is entirely empty, and this fact renders it certain that an actual union of the ducts with an opening does occur, and shows, too, that self-fertilization occurs as well.

It is important to note that here in *c* a vas deferens is formed, while in *a*, as mentioned above, the male duct is absent. The cause of this difference is indicated by the different direction of the partial furrows in the two cases. The partial furrows between *a* and *b* at the right extend obliquely backward posteriorly from without inward, and cut off from the segment *a* the region where the vas deferens would normally form, while the ventral furrow and the dorsal depression between *c* and *d* slant anteriorly, and thus a space is left in *c* anterior to the ovary where the vas deferens may form. The fact that the vas deferens opens into the seminal receptacle instead of extending to the pore, while the oviduct pursues a more nearly normal course, is perhaps not explicable on the basis of the form relations of the segments, but the suggestion offers itself that the close approximation of the two sets of organs, *c* and *d*, prevents its formation between them where it would naturally appear; so that it is confined wholly to the inner genital region. The oviduct of *c'* crosses the furrow to reach the pore instead of opening in its own segment. This is probably due to the fact that the degree of separation between the two segments is less than normal; for, as mentioned above, there is no distinct furrow on the dorsal surface, though ventrally the segments are sufficiently separated to give rise to separate ovaries. No pore at all is found at the right edge of *c*, and this is probably due to the same fact, *viz.*, that dorsally the degree of division is very slight, so that only one pore is formed for the two segments, though the position of this is apparently affected in some degree by the partial division which does exist, since it is placed somewhat anterior to the middle of the edge of *c d*.

In the genital organs *d'* of *d* relations are almost normal, but the oviduct is shorter than in *c'*, and the ovary is thus nearer the edge of the proglottid. The oblique direction of the partial fur-

row may perhaps account for this difference in position in the two sets of organs, for the line connecting the centers of the two ovaries lies at right angles to the furrow separating them, and the ovary of *d'* thus lies in a region where the segment *d* is longer than it is in the region where the ovary would normally appear.

The relation of the furrows and genital organs at the left of *c* and *d* requires little comment. The organs are normal in all respects. The two partial furrows approach close to the edge, but turn forward, becoming very slight, and soon disappear. The pores are somewhat less than the normal distance apart, for the furrows do not quite reach the edge. The curve forward of the outer ends of the furrows apparently does not affect the position of the genital organs, this portion of the furrows being very shallow.

Inter-proglottidal glands appear in all the partial furrows except the one between *c* and *d* on the right, and their absence in this part is undoubtedly connected with the slight development of the furrow.

Figure 22.

In the series of segments shown here there are a number of more or less incomplete furrows, and each is accompanied by abnormalities in the genital organs. The figure is a view from the ventral side.

The two furrows between the segments *a* and *b* correspond closely in position, except at the right, where the ventral furrow turns forward just before reaching the edge and ends on the ventral surface, but the dorsal furrow continues to the edge, where it ends. At the left neither of these partial furrows reaches the edge, though both end near it, the dorsal furrow nearer than the ventral. The genital organs at the right of these two segments, *a* and *b*, appear normal in form and position. The ovaries are the normal distance apart, as might be expected from the character of the furrows in the ovarian region. The two pores are equidistant from the dorsal furrow between them. At first glance the right pore in *a* appears to be quite close to the anterior boundary of the segment, but it should be noted

that the notch in the right edge which appears to separate *a* from *b* is really in *a*, for the dorsal furrow reaches the edge anterior to it, and the two pores are equidistant from this furrow. At the left side of *a b* there are two complete sets of organs opening to the exterior through a common pore which lies in the middle of the undivided edge of *a b*. In the region of the ovaries the furrows are normal, and accordingly the ovaries are nearly the normal distance apart. The left end of *a* is short, so that the full normal distance between the ovaries is not attained. Since the

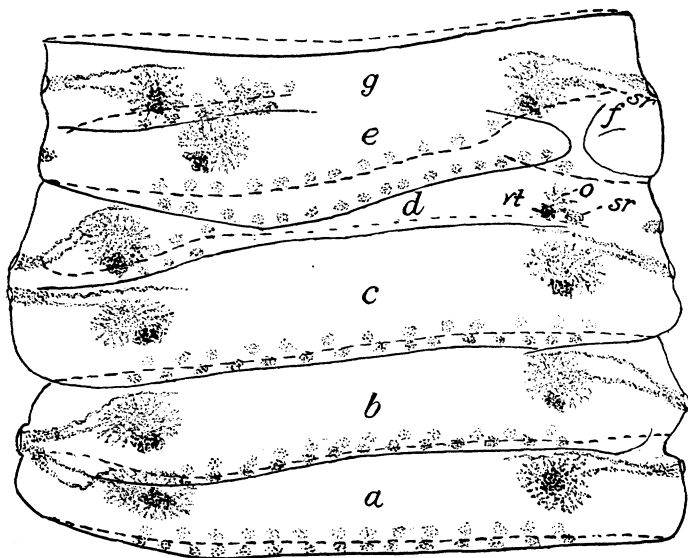


FIG. 22.

furrows do not quite reach the edge, it is undivided, and presents the relations of a single rather long proglottid. As might be expected, only one pore is present, though rather larger than normal, and into this the two oviducts and two vasa deferentia open, for the two sets of ducts approach each other as they reach the undivided region.

The segment *c*, of about normal length, and the segment *d*, which is of less than the normal length, except at the edge, are partially separated by two partial furrows which correspond very closely in position and extent on the two surfaces. The segment *c* is nearly the same length throughout, but *d* is longer at the

left edge than at the right and is very short in the middle region, and especially just to the left of it, in consequence of the bent course of the furrows bounding it anteriorly. At the right the two furrows between *c* and *d* end on the surface in the region of the ovaries, so that the right edge is undivided. At the left the furrows end very near to the edge, but do not reach it. The organs of the right side in *c* are normal; in *d*, however, they are rudimentary, consisting of a small imperfect ovary, *o.*, vitellarium, *vt.*, and a small closed and empty seminal receptacle, *s.r.*, and, entirely unconnected with these, a pore at the edge. No male organs except the cirrus appear. The absence of male ducts is perhaps due to the fact that this region of the segment *d* is shorter dorsally than ventrally, in consequence of the peculiar arrangement of furrows anterior to it. The pore of *d* is approximated to the pore in *c*, apparently because the furrows do not reach the edge. At the left edge *d* is of nearly normal width, though it narrows rapidly from the edge inward. Corresponding to its size the set of organs is of about normal size, like the left organs in *c*. These two sets open by distinct pores, which are, however, approximated.

The furrows anterior to *d* are very irregular. From the left edge they extend slightly posteriorly, thus almost separating *d* into two parts, then bend forward again and on the right end in a peculiar manner. The ventral furrow does not reach the right edge, but bends anteriorly and back upon itself, and ends on the surface. From the right edge the other portion of the furrow extends inward for a short distance, then curves back upon itself and ends. In the concavity of the curve near *f* a short isolated furrow appears. The furrow on the dorsal surface bends further anteriorly as it approaches the right edge and finally ends on the surface before reaching it. Posterior to this furrow lies another partial furrow corresponding to the right portion of the ventral furrow. It does not, however, bend back upon itself, but extends some distance to the left and then ends free on the surface. Thus a small region, *f*, is incompletely marked off as a partial segment on the dorsal surface, but ventrally the curved furrows divide into two parts. No genital organs appear in *f*.

The regions *e* and *g* are partially separated at the left by cor-

responding partial furrows, but at the right there is no separation, unless the region *f* be regarded as representing the right side of *e*. It is perhaps more correct to say that the right side of *e* is bounded ventrally by the left one of the two curved furrows, while dorsally *e* runs into *g*, and a small partial segment, *f*, mostly dorsal, laps over the edge to the ventral surface and fills the space left.

The furrows separating *e* and *g* on the left half of the body do not reach the left edge, though they end very near it. They are both rather shallow, thus indicating that the division between the two partial segments is less complete than normal.

The genital organs at the left of *e* present very peculiar and unusual relations. Ovary, vitellarium, and seminal receptacle of the normal size are present, and anterior to these and extending into *g* is a vas deferens which is closely coiled. This whole complex of organs does not lie in the normal position, but somewhat to the left of it, in the longest region of the partial segment *e*. I think it is possible that its position is due to the fact that the length is greater here than elsewhere. There is no trace of ducts leading to the edge; indeed, the oviduct beyond the seminal receptacle is absent, and the vas deferens does not extend even beyond the edge, but is coiled in a mass just anterior to the ovary. Doubtless this condition is due to the abnormally great distance between the organs and the edge. Careful examination of both surfaces of the region about the organs showed that there was no trace of a surface pore. I found, however, that the seminal receptacle was full of spermatozoa, a fact which indicates that the vas deferens opens directly into the seminal receptacle. The coils of the vas deferens were so dense and close, however, that it was impossible to find the connection. A pore corresponding to this set of organs exists at the left edge of *e*, but it is rather small and there is no trace of ducts leading from it. At the left of *g* there is a normal set of genital organs. On the right side of *e* *g* there is no division, unless, as suggested above, *f* be regarded as corresponding to *e*, and accordingly only one set of genital organs appears. In this the vas deferens is complete and normal, but the oviduct does not connect with the pore at all, ending instead with the seminal receptacle, *s.r.*, which is of

nearly normal size, but empty. It will be noted that furrows bounding *f* anteriorly end very near the region of the oviduct on both surfaces, and it seems probable that this abnormal condition is due to the position and direction of these furrows. The position of this set of organs as a whole is normal, and since the anterior of the two dorsal furrows does not reach the edge we find the pore in the middle of the edge *f g*.

The region *f*, although as large as some partial segments which possess at least rudimentary genital organs, shows no trace of any such. The ventral surface is cut by furrows in various directions, and this is probably the reason why no ovaries appear. The single pore at the edge of *g* is just between *f* and *g*, for the two are not separated at the edge, so that there was probably no tendency for another pore to arise in *f*.

Inter-proglottidal glands appear in all the transverse furrows which lie within the region of their occurrence, except the furrows between *c* and *d*. Here the glands appear only near the left ends of the furrows, but these portions are deeper and thus more nearly normal than the rest of these furrows.

Figure 23.

This figure, a dorsal view, shows two segments at a later stage of development, in which the uterus is formed, and the other

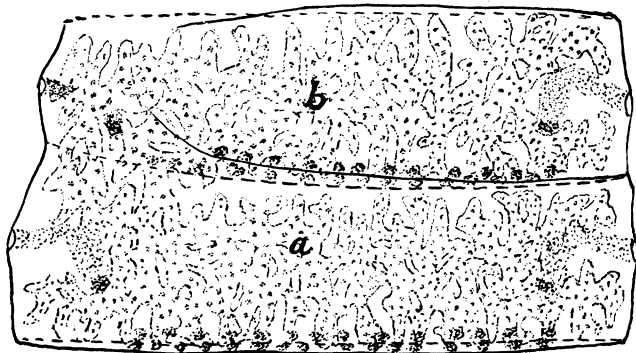


FIG. 23.

genital organs have undergone degeneration. The two segments are incompletely separated at the left, the ventral furrow being

shallow, but reaching the edge, and the dorsal furrow curving anteriorly and ending on the surface. The uterus is drawn in this case, and it is seen that the uteri of the two segments are continuous at the left, where the separation of the segments is incomplete. This is the only case of this kind figured, but continuity of the uterus is common in cases of partial division.

Regarding the other genital organs little can be said, as they are far advanced in degeneration. All appear to have been normal except at the left of *b*, where the pore and vitellarium are still visible, but no traces of ducts appear, and only a few cells in the ovarian region. A more or less rudimentary condition of these organs might be expected, for this portion of the segment is of less than normal length and dorsally is not marked off from either of the segments adjoining.

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